which formed its vehicle. In fact the author remarks that the absorption of terrestrial rays by the odour of a flower-bed may exceed in amount that of the entire oxygen and nitrogen of the atmosphere above the bed.

Ozone has also been subjected to examination. The substance was obtained by the electrolysis of water, and from decomposing cells containing electrodes of various sizes. Calling the action of the ordinary oxygen which entered the experimental tube with the ozone unity, the absorption of the ozone itself was in six different experiments 21; 36; 47; 65; 85; 136. The augmenting action of the ozone accompanied *the diminution of the size of the electrodes* used in the decomposing cells. The author points out the perfect correspondence of these results with those of M. Meidinger by a totally different method of experiment. The paper contains various reflections on the nature of this remarkable substance.

February 6, 1862.

Major-General SABINE, R.A., President, in the Chair.

The following communications were read:—

I. "Remarks upon the most correct Methods of Inquiry in reference to Pulsation, Respiration, Urinary Products, Weight of the Body, and Food." By EDWARD SMITH, M.D., LL.B., F.R.S., Assistant Physician to the Hospital for Consumption, &c., Brompton. Received January 9, 1862.

Having been engaged in several researches into the vital actions of the human system, which have extended over lengthened periods, I have necessarily formed opinions as to the best methods of inquiry, and have noticed some circumstances which tend to induce incorrect results. On consideration it has appeared to me that it might serve the interests of science as much to solicit the attention of present and future investigators to the circumstances connected with the mode of inquiry, as to adduce the facts which the inquiries have elicited; for it cannot be doubted that nearly all the errors which have found place in this department of physiology have been due to deficiency in the methods of inquiry, whereby only a part of the results arrived at were

obtained from actual observation; and hence much valuable labour has been lost and science has been led into erroneous channels. I have therefore ventured to lay before the Royal Society, with a view to publication in its 'Proceedings,' a short summary of the conditions which I believe to be essential to the elimination of truthful results in inquiries connected with the rate of pulsation and respiration, the quantity of air inspired, of carbonic acid expired, and of urinary water and urea excreted, the weight of the body, and the influence of foods; and in so doing I purpose first to consider the inquiries into the daily quantities of each of them, and then to refer to each subject separately.

1. *The determination of the daily quantities.*

In none of the subjects for inquiry will observations made at one or a few periods of the day enable us to infer the total daily quantities, since there are scarcely any two hours in which the quantities remain unchanged; and although the variations, for the most part, follow a definite course, the progression is not so uniform that, even under the most favourable circumstances, they may be safely inferred.

The rate of pulsation and respiration varies in such a manner that it is increased after each meal during about two hours, and then declines for about an equal period, unless food be in the meantime taken. There is a less proportionate increase and decrease after the early dinner and tea than after breakfast, and at about 8 or 9 P.M. the rate falls rapidly and continually until the middle hours of the night. The nearest approach to a stationary rate occurs—1st, in the middle hours of the night, with a tendency to increase; 2nd, after rising and before breakfast, with a tendency to decrease; and 3rd, in the afternoon, when the midday meal has been deferred, with a tendency to increase at the usual meal-hour. The least stationary periods are the three or four hours following each meal, and the late hours in the evening. In the total absence of food throughout a whole day, the rate remains nearly stationary from the hour of rising in the morning until about 9 P.M., with a tendency to change at the usual meal-hours.

The quantity of air inspired and of carbonic acid expired is subject to similar variations; but the increase after the early dinner is less, and that after tea is greater than that of the rate of pulsation, and the rate is more constant before breakfast and throughout a day of fasting.

The rate of evolution of urea is less uniform than that of either of

the above-mentioned subjects of inquiry, since it depends more upon the conditions of the preceding day, and upon the variations in the amount of fluid ingesta. It is, however, the least during the night, and then in the morning before breakfast, but it is not stationary at the latter period. It rapidly increases after breakfast for the space of about three hours, and then decreases even more rapidly, and continues low, notwithstanding the early dinner, until the tea hour, after which it again rises, and finally it falls at about 9 or 10 P.M. until the night-rate is attained.

The rate of production of urinary water follows the order of that of the emission of urea, except that the increase in the afternoon is much less, and there is an approach to uniformity of production after about 3 P.M.

Hence, with the exception of the excretion of urea after the early dinner and of urinary water in the afternoon, there is a progressive increase followed by a progressive decrease in all the subjects of inquiry after each meal, and therefore several such alternations occur during each day. There is also a low rate in the night and immediately before each meal.

The only correct method of determining the daily quantities is to collect the whole. This may be effected at rest, or with mixed rest and exertion, in reference to the urea and urinary water. So also in reference to the air inspired and carbonic acid expired, except that as to the latter the degree of exertion must be limited, and attention to the daily duties of life nearly intermitted. I do not think that the total number of pulsations and respirations can be recorded except by the process of counting, since the registering instruments are liable to fail, and an error cannot be corrected. The nearest approach to correct results, short of the foregoing, will be made by observations taken at regular and frequent periods during the 24 hours; but the period of intermission must not exceed one hour, and it need not be more than a quarter of an hour.

A rough estimate may be obtained by taking the average of the four maxima and four minima of the rate of pulsation and respiration, and the quantity of air and carbonic acid, if the inquiry be limited to the 18 working hours of the day, viz. 6 A.M. to midnight. If the meals be taken at $8\frac{1}{2}$ A.M., $1\frac{1}{2}$, $5\frac{1}{2}$, and $8\frac{1}{2}$ P.M., the periods of inquiry will be 8 and $10\frac{1}{4}$ A.M., 1, $3\frac{3}{4}$, 5, 7, 8, and 10 P.M.

The determination of percentage quantities is worthless for this purpose, unless the total quantities of air or urinary water be also ascertained and employed in the calculation. As the per-centage quantities vary greatly, it is necessary that the daily quantities be determined to a uniform hour; and the best period is that which immediately precedes breakfast.

2. *General considerations affecting each subject of inquiry.*

Pulsation and Respiration*.

In instituting any inquiries into the rate of pulsation and respiration, the following conditions are required:—

The posture of the body must be uniform; and as the sitting posture has a rate nearly intermediate between that of lying and standing, it should be universally preferred, except in inquiries into the influence of sleep, or on the sick often confined to the couch, when inquiries in the lying posture are alone practicable. The posture should remain quite unchanged during the whole time of the inquiry, also for at least five minutes before its commencement, if the person has been previously at rest, and fifteen minutes in the case of previous exertion. The attention must be withdrawn. Care should be given to ascertain if the rate is influenced by a feeling of nervousness, or by any other disturbing cause; and if so, the inquiry must be deferred until the rate has become uniform. There are also conditions, however absurd it may appear, when the observer is liable to mistake the pulsation in his thumb or finger for that of the person under inquiry. The rate should be counted during two minutes if practicable, and in no instance less than one minute. Half a respiration should be recorded; and the counting should be commenced only from a long line on the watch dial. It is often very difficult to count the respirations during quiet sleep in the night, and even during wakefulness, in many women, notwithstanding close observation of the movements of the alæ of the nose and of the upper part of the chest; and in such cases the hand must be slightly applied to the chest. Coughing, yawning, and dreaming temporarily accelerate the pulse. It occasionally occurs that the rate of respiration or pulsation becomes doubled or halved; and intermitting pulsation often occurs in children and feeble persons during sleep, whether by night or day. In comparing the rates upon

* See Medico-Chirurgical Transactions, vol. xxxix. 1856.

different days, care must be taken that the inquiries are all made at rest, at the same hour, in the same posture, and at the same period after meals ; and even then the results will be liable to great variation. No comparison can be made of the rates at different periods of the year, nor indeed on any two consecutive days, if there have been any considerable atmospheric changes or material variation of the daily habits. With increase of temperature the rate of pulsation increases, whilst that of respiration declines. The effect of moderate exertion continues for several minutes, and of severe exertion for about half an hour. An unusual rapidity of pulsation in one half of the day will be attended by the opposite state in the other half, if the conditions have been changed at those periods,—as, for example, an increase from exertion, followed by rest, or a decrease from fasting, followed by food. Extreme differences of 30 pulsations per minute occur in the 24 hours. The chief objection to the use of instruments to register the rate is their liability to miss the record from the difficulty of closely applying them to the wrist or chest, and the great variations in the extent of pulsatory and respiratory movement in sleep and wakefulness.

The usual practice amongst medical men of ascertaining the rate of pulsation, regardless of posture of the body, of meals, and of the hour of the day, is evidently liable to the greatest error. In order to obtain even approximately correct results, the visit should be made at about the same hour daily, and the inquiry pursued always in one posture.

Quantity of Air inspired *.

The same attention to posture is required as that noted under the previous heading. It is more satisfactory to measure the inspired than the expired air, since no correction is required for expansion by heat. Moreover, when the object is to ascertain the vital capacity of the lungs, it is important to remember that the inspiratory force at the end of a deep inspiration is greater than the expiratory force at the end of a deep expiration. It is necessary to cover or close the nose, since otherwise a portion of air is unconsciously inhaled through it. If a tube be inserted into the mouth for the purpose of inspiration, the lips must be closely pressed against it, and particularly at the angles of the mouth ; but there are many persons who cannot

* See Phil. Trans. 1859.

close the lips perfectly with a tube placed in the mouth. When it is desired to measure ordinary inspiration, it is advisable to use a mask which encloses the chin, nose, and mouth, so that inspiration may proceed easily and naturally through both openings. The sides of the mask must be made of lead, so thick that when pressed upon the features it will retain its position; and it should be lined with sheet caoutchouc, the better to adhere to the skin. The face must be well introduced into the mask, and the thumbs placed under the chin whilst the forefingers cover the free edge of the mask so as to press the lead to the face and prevent any ingress or egress of the air either at the bridge of the nose or on the sides. Persons with large beards, and those with very thin and sunken cheeks, cannot use the mask effectually. After the mask has been worn for some time the vapour condenses within it, and the fluid trickles beneath the chin, when it will be very difficult to prevent a little air entering until the mask shall have been removed and wiped. The mask may be held upon the features by bands which cross the head transversely and longitudinally. Care must be taken that the valves close well and act easily. If the mask has been laid aside for some time, the valves will have curled up; and it will be necessary to place it in luke-warm water for half an hour, or to pour water upon the dry valves. The measuring-instrument should offer but a very small amount of resistance to the expired current of air; so that, if it be a gas-holder, as in Hutchinson's and Davy's spirometer, it should be accurately counterpoised at every part of its progress; or if it measure and register ordinary inspiration, the adverse pressure should not exceed $\frac{2}{10}$ths of an inch of a column of water. The person must breathe normally, by the aid of previous training and by abstracting the attention. If there should be any sense of constriction about the chest, it may be inferred that the respiration is not normal, and that the chest is either too much collapsed, so that the act of expiration is too prolonged, or it remains expanded above the ordinary degree, and the act of expiration is shortened. The sense of ease and satisfactory respiration must be at all times present. Hence practice and intelligence are necessary. The experiments must embrace several minutes at a time; for a respiration rarely ends at a complete minute, and must therefore be recorded as a fraction, and the attention cannot be abstracted in the short period of one minute. Results obtained from

observations of so short a duration cannot be uniform. The aim must be to ascertain the precise number of respirations and the quantity of air inspired then occurring. To control the respiration by inspiring a predetermined number of times per minute, or by breathing with an assumed uniformity of depth, is to render the act and the results alike unnatural. It is doubtless possible to fix the number of respirations, but it is impossible to regulate the quantity of air inspired except by the aid of a spirometer. The effect of exertion may be accurately determined by fixing the mask upon the face with bands, and by carrying the spirometer in the arms, or fastened upon the back with knapsack straps. The instrument must not exceed a very few pounds in weight. The distance to be traversed must be accurately measured, and subdivided into short distances also accurately measured, so that, with the watch in hand, the rate may be tested every half minute and over every small part of the course. Eaeh subdivision should be a known part of a mile, and at the rate selected must be traversed in a given number of seconds. Thus, at the rate of two miles per hour, a course of $58\frac{2}{3}$ yards would be traversed every minute; and if that be subdivided into six equal parts, each one would be walked over in a very little less than ten seconds.

The Carbonic Acid expired*.

The remarks already made in reference to posture and rest are also applicable to this subject. It is impossible so to regulate the respiration that a fair average of the carbonic acid evolved may be made from inquiries of one or two minutes' duration, both from the impossibility of withdrawing the attention, and of obtaining an exact proportion of the expiration in so short a time. We almost always found that the rate of respiration was greater during the first than during subsequent minutes; and this was no doubt attended by a change in the quantity of carbonic acid expired, and it was due to the action of the mind. Five minutes is the shortest period during which such an inquiry should be continuous, and ten minutes would be better if the duration of each experiment should not interfere with the necessary frequency of repetition; but the latter might be an essential character of the inquiry. An inquiry of five minutes duration may be repeated every twelve minutes. The apparatus' required must be

* See Phil. Trans. 1859.

capable of containing the products of respiration during five or ten minutes, or must absorb them as fast as they are emitted. There must be no adverse pressure upon the respiration. In collecting the expired air in a bag, there will be the fallacy of not being able to empty the bag completely; and unless special care be taken, there will be an adverse pressure from the weight of the sides of the bag, and from their cohesion. Moreover, it is impossible to measure the expired air by such means; and if it be passed through a spirometer, there will be a fallacy from the pressure required to move the instrument; or if it be passed into a graduated tube, there will be a change of bulk from temperature and pressure. If only a part of the collected air be submitted to analysis, it will be very difficult to obtain a fair sample, since the specific gravities of the component gases vary much. In seeking the absorption of the gas, it is essential that the expired air should not be forced through a layer of fluid, since the adverse pressure upon the respiration would cause either defective expiration or an increased effort to expire, and in both cases error, but in opposite directions, would occur. No arrangement of solid absorbents with moistened surface can be so made that it shall absorb all the carbonic acid during the process of expiration. No combination of tubes within tubes, with a view to increase the absorbing surface, can be arranged within a manageable space and weight suited to this purpose. Hence it is requisite that the expired air be passed *over* a fluid; and the fluid must be capable of rapidly and certainly absorbing the gas, and offer so large a surface that it may be found by experiment capable of absorbing the whole of the carbonic acid during the period of expiration. The air should be exposed in thin layers to the surface of the absorbent, and only a small column of it be offered at the same moment, so as to allow a long period to elapse before each small portion of the expired air shall have traversed the whole surface. A test apparatus should be attached at the end, and the test be occasionally applied during the inquiry, so as to ascertain if any unknown cause of error exists. Any portion of the absorbing fluid which may have been carried along by the current of the previously dried air must be arrested before the air escapes into the atmosphere, and no element of the expired air, besides the carbonic acid which the absorbent might retain, must be allowed to enter the absorbing apparatus. By this method the amount of carbonic acid

is determined by the increase of the weight of the absorbing apparatus; and hence it is necessary that the latter be such that it may be weighed to not less than the $\frac{1}{10}$th of a grain. Gutta percha is the only known substance of which the apparatus may be constructed, since it is not greatly acted upon by the caustic alkali, may be readily formed by the aid of the hot iron, and does not allow the fluid to flow over the floors of the chamber with the readiness observed when glass or metal is used, during the act of weighing. The only practical absorbent is a solution of caustic potash, and its spceific gravity should be 1·270. The atmospheric air which will enter the various parts of the apparatus when not in use, must be expelled by blowing expired air through them before they are counterpoised as a preliminary to the inquiry. The expired air must not be reinspired. Hence boxes such as that employed by Scharling are inapplicable; for, however rapid the current of air which is drawn though the box, it is quite certain that some portion of the air will be again and again inspired, and moreover the dilution of the air charged with carbonic acid renders the absorption of the gas much more difficult, whilst the determination of the carbonic acid remaining in the box is always a circumstance of great difficulty. When a mask is worn, it should not have a capacity larger than necessary to contain the features, or it will retain expired air, which must be reinspired. When respiring through a tube placed in the mouth, it is exceedingly difficult to prevent the escape of air, whether as it is introduced into or withdrawn from the mouth, and the results cannot be relied upon. If the nose be left unclosed, a variable and unknown quantity of air will enter and leave by that aperture. The effect of exertion may be readily ascertained by using a tube 15 feet in length attached to the mask and the analytical apparatus. The apparatus must be placed in a central position, and a space of 30 feet marked out in a right line, and this must be walked over at a defined rate of speed. The potash-box must be made of larger size than that required for experiments upon quiet respiration, or two sets of the apparatus must be used at the same time. In the latter case there will be danger of adverse pressure from the air passing through so many vessels; and if the exertion in breathing be considerable, it will be impossible to measure the inspired air at the same time. The tubes must be of sufficient diameter and of smooth material, and be filled with expired air before the experi-

ment commences. These observations also apply to experiments upon voluntary respiration, where the force, depth, and rapidity exceed that at rest. A space of 1000 to 1500 superficial inches of absorbing surface will be necessary with exertion, whilst 700 inches is sufficient at rest.

There is a variation in the quantity of carbonic acid expired on different days of the week, so that there is an increase after a day of rest. There is also a variation with the season of the year, so that the evolution is the greatest in the spring, then in the winter, and then in the autumn, and it is the least at the end of summer. It increases with cold, and decreases with heat. Hence the quantities evolved at various seasons cannot be compared, neither indeed those in a short period of days, if there have been any considerable changes of weather or habits. The only mode by which the rate of evolution in different days and in different seasons may be compared is by making observations in the morning before food has been taken, and in absolute rest, so as to isolate the effects of season and meteorological phenomena from every other influence except the small effect of the conditions of the previous day. This method is almost without fallacy.

Urinary Water and Urea*.

The urinary water should be collected in tall and narrow glasses which are graduated to $\frac{1}{10}$th of an ounce, and covered to prevent evaporation. When travelling, $\frac{1}{10}$th of the quantity emitted at a time may be reserved, and the larger portion thrown away. The glasses must be used during defæcation; and hence such inquiry cannot be accurately made in women. The various quantities must be retained and collected to the exact termination of each 24 hours; and after they have been mixed and reduced to the temperature of the air, a sample should be taken for analysis. As the urine decomposes readily in warm weather and when the specific gravity is very low, the analysis must not be deferred later than two days; but in the opposite conditions four days may elapse.

There are very great and rapid variations in the quantity of urine evolved; so that large and small quantities may alternate daily, or a sequence of increase or decrease may be established, or one may follow the other for many days. Hence a correct daily average can

* See Phil. Trans. 1861.

only be obtained after perhaps ten days of inquiry: and the quantity observed in one season will not apply to that of any other season; so that the effect of season can only be ascertained by continued inquiries through the year. Rest, diminished ingestion of fluid, increased ingestion of animal solids, increased temperature and atmospheric pressure, profuse discharges from the skin or bowels, and increased bulk of the body from whatever cause, all other things being equal, will lessen the excretion of urine. The contrary conditions, each one, other things being equal, will increase the excretion of urine. The action of any two of these agents, each in an opposite direction, will modify the influence of the other. It must not be inferred that there will be lessened excretion of urine because there is increased excretion of fluid by other outlets, as the skin, unless it be proved that there was no increase in the quantity of fluid ingested and no diminution in the bulk and weight of body. Urinary water is largely and quickly excreted when fluid is drank without any solids having been taken on that day, viz. before breakfast, but to a much less extent if solids have been previously taken, and still less when solids are taken with the fluid. The maximum rate of emission must be sought for between the breakfast and 1 P.M., and by experiments made not less frequently than a quarter of an hour. The minimum quantities occur in the night, and continue for much longer periods. All graduated glasses, alkalimeters, and pipettes should be graduated and carefully proved by the observer before using them, and this may be conveniently and most accurately effected by the balance.

In pursuing Liebig's volumetric method for the determination of urea in the urine, it is essential that the operator have graduated the mercurial solution himself, or have made himself familiarly acquainted with the tint of colour to which it is graduated by repeatedly testing it with the proper quantities of pure urea. Moreover, as the recollection of the precise tint to which the solution was graduated fades from the memory, the test quantity of urea should be used from time to time to renew it. The urea to be used must be proved to be perfectly pure. The solution should be made in a quantity of several gallons, and be drawn from the carboy by a siphon with the smallest apertures, so that the standard strength may be preserved. The quantity in daily use for the supply of the alkalimeter should not

exceed a few ounces, and the alkalimeter must be washed out with distilled water after each operation has been finished. Care must be taken to force out the bubble of air which is retained in the neck of the exit-pipe before the operation begins. If it be possible, the analyses should always be made in the same amount and kind of light, since otherwise there will be an incorrect perception of the proper tint. The direct rays of the sun, and even too bright an indirect light, must be avoided as much as a deficiency of light. It is not possible to use artificial light. The thickness of the layer of the solution of carbonate of soda should be uniform, since there will be a difference in the tint and the rapidity of its production in the shallower and the deeper parts. From one to two minutes must be allowed for the production of the colour when it approaches the standard tint. Dr. Guy's spatula is to be preferred to Dr. Beale's suction-tube, since it retains a less quantity of the thick fluid from the previous immersion. It often occurs, in the analysis of coloured urine (as in urine of high specific gravity), that the distinction of the tint is not well appreciated if the solution be added in quantities of one division only; and hence it is often better for the experienced investigator to add two divisions of the solution at a time, so as to produce a little excess of colour, and then to compute and deduct the excess. In urine of low specific gravity, the tint is quickly and distinctly produced by half a division of the solution. The specific gravity of healthy urine is a ready guide to the addition of the first and large quantity of the solution. In a healthy person, and one of regular habits and under ordinary conditions, the daily quantity of chloride of sodium which is eliminated and must be deducted from the urea is tolerably uniform; and the quantity having been ascertained by numerous trials, it may be used for the same person as a constant quantity, where absolute accuracy is not essential, and thus the labour will be materially lessened. With urine of a specific gravity from 1012 to 1025, it is convenient to add by the pipette $\frac{1}{2}$ an ounce of urine to $\frac{1}{4}$ ounce of the baryta solution. When the specific gravity exceeds 1025 (in the absence of sugar), equal parts should be used; when it is below 1012, it is needful to add 3 or 4 parts of urine to 1 part of baryta solution, and with diabetic urine 4 parts should always be added. A quarter of an ounce of the mixed fluids should be taken with the pipette, and the number of divisions of the mercurial solution used to produce the

tint must be multiplied by the following factors to determine the amount of urea per ounce:—

With equal parts of each multiply by................	8
With 2 parts of urine and 1 part of solution of baryta multiply by	6
With 3 parts of urine and 1 part of solution of baryta multiply by	5·33
With 4 parts of urine and 1 part of solution of baryta multiply by	5

Considerable and constant practice is essential to correct and comparable results.

The periods of the formation and the elimination of urea are different, and there is no known method of showing the former. The urea from metamorphosis of tissue and from the transformation of food is a mixed and varying product, and the two sources cannot be dissociated. The direct relation of urea is with food, since, in the absence of exertion, it nearly represents the nitrogen in the food supplied, less that remaining in the fæces. The elimination of urea chiefly varies with the quantity of urine, and therefore will be influenced by the same agencies as affect the discharge of urine. Hence the duration of inquiries to determine the normal daily rate of elimination at distant periods of the year, must be the same as that indicated in reference to the urine. There are great and frequent variations in the daily elimination of urea in a person of the most regular habits; and as the effect of any agent is often carried on to the following day, inquiries which may be made for a short period before breakfast will not faithfully represent the conditions of that day.

Weight of Body*.

The only satisfactory method of determining the weight of a person day by day, is to weigh him naked directly after he has passed urine and before he has taken any ingesta, and to do so as nearly as possible at the same hour every morning. The error which will be due to the varying amount of fæces contained in the bowel will still exist, but it cannot be large, and by no method can it be entirely removed. The person cannot weigh himself unless stand-scales with a multi-

* See Phil. Trans. 1861.

plying lever be employed. It will usually suffice to weigh to $\frac{1}{2}$ or 1 oz. The weight of the body will be influenced by the quantity of food taken, and by all the circumstances already noted in reference to the emission of urine. Hence the body is heaver at night than in the morning, also after a day of rest than after labour, in warm than in cold weather, and in all conditions in which the bulk of the body is increased, and the elimination of fluid lessened. There is a close relation between sudden changes in the quantity of urine evolved and the weight of the body. Among the excretions which cause a variation in the weight of the body, the carbonic acid, although a gas, must not be overlooked; and so far the weight will vary as the conditions above mentioned vary the production of carbonic acid. Hence, upon the whole, the determination of the weight at night is attended by greater liability to error than in the morning, and the latter period would alone suffice for the inquiry. A variation in the weight occurs almost daily, and under some circumstances it amounts to from 1 to 2 lbs. The varying weight of the body represents the varying quantity of the fluid and solid excretions, the fat and the fluids in the blood-vessels and tissues, besides the nitrogenous elements of the body. Under the discipline of a prison, there is the highest proportion of nitrogenous tissues to the weight of the body.

Food*.

The effect of food upon the system may be sought in two ways:—1st, the general effect of the ordinary dietary, which will represent the actual condition of the body in the individual or in the masses, but not the separate influence of any food. This is of great importance when considered in relation to the community, and may show its actual state under ordinary conditions. For this purpose the methods of inquiry already referred to under the different subjects will suffice. 2nd, the effect of separate articles of food only. This can only be ascertained in the absence of every agent acting upon the system, except the one in question. Hence the food must be taken alone, and before any other food has been eaten on that day, viz. before breakfast. The inquiry must also be made with precisely a uniform degree of exertion, and therefore at rest only, and in the absence of all excitement and meteorological changes. If an unusual kind or

* See Phil. Trans. 1859.

quantity of food be given, it will probably disturb the system and give inaccurate results. It is necessary to give a moderate dose, and in the customary form. The effect of all agents is temporary, and that of all kinds of food begins quickly and attains its maximum within 1 to $2\frac{1}{2}$ hours. If the maximum effect only be sought for, that period will suffice for the inquiry; but if the average or total influence be desired, it will be necessary to continue the inquiry until the whole period of increase and decrease, or *vice versâ*, have passed over. In either case the experiments must be made every few minutes, and be regularly repeated. The maximum quantities are easily attainable, but the true average or the total effect is scarcely if at all so, since it is difficult or impossible to ascertain the precise period of the termination of the effect. Hence only one dose of the food can be given on the same day, when great accuracy is desired. A second period may be found at about $4\frac{1}{2}$ hours after the breakfast; but, although it is next in value to the period before breakfast, it cannot be implicitly relied upon, since no proof could be obtained that the vital functions had subsided from the breakfast increase to their lowest point before the inquiry began. All such experiments must be tested by morning inquiries. Whenever there is a sense of craving for food, or any disturbed feeling, it is highly probable that the vital actions are varying, apart from the influence of the food, and the inquiry should be terminated. The addition of water to the food does not vary the results connected with the respiration, except so far as it may enable the food to enter the circulation quickly. If the solution of the food have been imperfect, the subsequent ingestion of water alone will cause an increase in the effect equal to that of taking more food.

II. "On the Motions of Camphor on the Surface of Water." By CHARLES TOMLINSON, Esq., Lecturer on Science, King's College School, London. Communicated by Dr. WILLIAM ALLEN MILLER, Treasurer and V.P.R.S. Received January 15, 1862.

(Abstract.)

The object of this paper is to show that the phenomenon in question is a much more general one than is commonly supposed; that